In the drawings:

Please replace drawing sheets 1 with the attached sheet.

Remarks

1) Applicant thanks the Examiner for his office action and for the interview granted and conducted June 21, 2005. Applicant hopes that this response will further the understanding of applicant's invention.

2) Applicant agrees that the interview summery report generated during the interview reflects the interview content and does not wish to add to or modify it.

3) Claims 1-51 are pending in the application. Claims 1-12, 14-24, 26, 29-32, and 35-41 stand rejected under 35 U.S.C. 102(a) as being anticipated under Bulst (US 4,679,014). All other claims are being objected to as being dependent from a rejected claim but are otherwise allowed if rewritten in independent form. Claims 52-56 were added to claim matter not claim heretofore, to which applicant believes he is entitled.

4) Applicant amended without prejudice, independent claim 1 to positively claim the fact that each transducer comprises interdigitated electrodes coupled in some periodic sequence, to a plurality of electrical nodes. Thus the transducers are differentiated from non-active elements such as passive, and/or grounded electrode elements that may be present within the active grating. To further clarify the structure, applicant added the language that describes the reflective grating as continuous and periodic. Applicant points out that those amendments are not narrowing, but added for clarity of certain characteristics of transducers and the reflective grating that applicant believe are inherent to the disclosed structure.

5) The applicant wishes to thank the Examiner for clarifying his interpretation of the claim language. This assisted the applicant to identify that the Examiner considered the claim to read on Figs. 1 and 2 of the present application. However, applicant respectfully points out that the figures mentioned relate to prior art rather than to the present invention. While this fact was pointed out in the specifications (e.g. paragraphs [0010] and [0014]), applicant amended the

drawings to show more clearly that the figures relate to prior art.

6) The Bulst et al. reference (US 4,679,014) discloses an improved method for projection photolithography of both transversal and resonator filters. In setting forth their invention Bulst et al. relate their invention to the making of resonator filters (column 1, lines 26-30). Resonator filters are well known and their operation is further explained in paragraphs [0014] – [0017] of the present application, including an outline of their deficiencies with respect to the present invention.

7) Bulst does not specifically teach any desired relationship between the ranges provided for transducers and reflectors. However, as Bulst is silent regarding any desired correlation, one needs to apply common knowledge in the art to create a structure according to Bulst, which will not destroy the function of the Bulst device. The conventional structure of a two pole resonator is well known in the literature and has well known design limitations that DIRECTLY CORRELATE the number of strips in the transducers and the number of strips in the reflectors.

8) Applicant provides herewith several examples representing the common teaching in the art of resonator filter designs. Those references uniformly show the desirability of minimizing the electrode count of the transducers as compared to the electrode count of the reflectors. The consistently low ratio of transducer length to overall length in these examples further indicates the functional limits that the purpose of the resonator filter dictates on any practical design. The literature thus bolsters applicant's position that the Bulst ranges were taken out the context of design constraints and the state of the art, only to obtain an unrealistic example of 66% transducer coverage, and that a respective correlation exists between the electrode counts of the transducer and reflector ranges, in order for the Bulst device to function for its intended purpose as a resonator filter. Therefore, when taken in context, the Bulst patent does not disclose the embodiment alleged by the Office, nor the claim limitations.

9) Applicant also prepared several mathematical models of resonator filter devices, with varying ratios of transducer to reflector electrode count. The models and basic analysis thereof are provided in Appendix 1, filed with this amendment. Applicant further added a general discussion of what is believed to be most prominent events in the development of acoustic wave resonator filter development, and their applicability to the design considerations of the transducer/reflector electrode ratio.

10) A simple analysis of the mathematical models provided show that as the ratio of transducer elements to reflector elements increase, the rejection of spurious resonances and stopband signals decreases. Therefore it is clear that while Bulst et al. provides ranges of numbers of electrodes, those numbers should be correlated for the reasons detailed herein. Bulst is silent regarding the transducer/reflector electrode count. When considering the Bulst reference as a whole, in light of the state of the art, making a device that uses a high ratio of transducer/reflector electrodes will destroy the intended function of a filter resonator of the Bulst device. Therefore, the Office proposed combination will cause the Bulst device to become unsatisfactory for its intended purpose, and the state of the art dictates a correlation between number of transducer and reflector electrodes. Applicant respectfully submits that Bulst fails to disclose the claimed limitation in sufficient specificity to constitute anticipation. Therefore, applicant respectfully submits that the interpretation the Office provided of the Bulst patent uses impermissible hindsight and that Bulst does not anticipate the limitation of transducers that cover at least 60% of the acoustically active area, as claimed.

11) Claims 52-56 where added to more distinctly claim higher ratios of transducer to reflector electrode count.

12) Applicant has made a good faith effort to address each and every point made by the Examiner, and amended the claim in order to place the application in condition for allowance. Should the Examiner find any deficiency in this amendment or in the application, or should the Examiner believe for any reason,

that a conversation with applicant's agent may further the allowance and issuance of this application, the Examiner is kindly requested to contact Shalom Wertsberger at telephone (207) 799-9733.

In light of the showing and all other reasons stated above, applicant believes that the rejections and objections presented by the Office in the final office action mailed to applicant May 31, 2005 were overcome. Applicant therefore submits that the claims as amended are in condition for allowance. Reconsideration and withdrawal of the rejection and issue of a notice of allowance on all pending claims is respectfully solicited.

Respectfully submitted

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Appendix 1
Correlation of Transducer Length to Reflector Length

In a typical resonator or resonator filter, as described by Bulst and by numerous examples in the literature, discussed below, it is an object of the design to obtain a single prominent electrical resonance or passband of high quality factor and good electrical efficiency while rejecting competing frequencies.

While the Bulst reference states some wide ranges of electrode count in the transducers and the reflectors, in order for the Bulst device to operate for its intended purpose a correlation between the number of electrodes in the transducers and reflectors is required. The correlation is argued on fundamental principles expressed in the early literature on such devices and a fundamental upper limit on the ratio of transducer electrodes to total electrodes is derived. In order to clearly show this requirement, applicant provided herein a number of examples of designs for the Bulst type inline acoustically-coupled resonator filter and simple resonators. The example resonators and filters show varying relationships between the number of electrodes in the transducers and reflectors respectively. The examples were derived utilizing MathCAD® models based on the well-known coupling of modes formalism. The models employ the well-known "coupling of modes" solutions developed by Peter Wright and expanded upon by Ben Abbot (U. Central Florida PhD Dissertation).
The applicant attests that utilizing such models is a common practice in the art of designing resonator filter devices, and that his personal experience had shown those models to produce results that reflect closely on actual behavior of the devices designed in this manner, as shown in the attached paper by King et al. (1987k).

Since coupled resonator filters have relatively narrow bandwidths, temperature stable quartz is favored. Quartz offers a high ratio of reflectivity to transduction efficiency and <u>will favor longer transducers relative to the reflectors</u> than will langasite, gallium phosphate, lithium niobate, lithium tantalate or other more strongly piezoelectrically coupled materials. This will bias the calculations to higher transducer ratios and provide a more stringent burden of demonstration on the applicant. For those reasons, quartz was selected as the material for the examples provided herein.

Materials with lower coupling, such as gallium arsenide, will deteriorate less rapidly than does quartz; however the practical upper limit for the percentage of a resonator covered by transducers remains below an upper limit of ~40% based on

the fundamental argument provided below, whereas this is the lower limit of coverage for a practical multi-reflective acoustic wave device (MRAWD) of the present invention as claimed.

In 1974 Staples first presented the SAW resonator using lithium niobate with 200 reflector elements in each of 2 reflectors and no more than 8 transducer elements for a transducer coverage of only 2% of the entire device (**1974s**). Staples identified a requirement of a high-Q resonator to have better than 96% reflectivity of the energy trapping outer reflectors. This condition, which is tightened by subsequent practitioners, sets a lower limit on the number of elements in the outer reflectors, N_R, which are assumed equal to each other and to the smallest possible number of reflectors to obtain >96% overall reflectivity. This number was seen to be related to the impedance mismatch between the reflective stripe and the space between stripes. Cross (**1975c**) quantified the relationship in terms of the reflection coefficient (denoted as κ in the present patent application and ε in his paper).

In 1975 Staples presented a paper (**1975s**), in which he employed two mirrors of 200 reflecting stripes and a single transducer of 81 stripes (16.8%) on ST Quartz for a single pole, single port resonator. This supports the assertion that quartz will favor maximization of the transducer to total device length ratio ("transducer ratio") over other stronger piezoelectric materials. With the advent of lower piezoelectric coupling materials the effect of the transducers became significant. Haydl (**1976h**) presented information on the reflective screening effect of the transducer within the resonant cavity as a result of comparing equivalent lithium niobate and quartz designs with 4.5 and 30 periods of transducers (N_T), respectively. He stated, "*Although the cavity length corrections should be negligible, f_o is shifted toward lower frequencies, and a strong second mode at the lower edge of the reflector stop band is observed. From these experiments it can be concluded that the transducers and the cavity filling stripes cannot be neglected.*" It should be noted that the practice at the time was to place transducers at the loci of maximum coupling, which was not synchronous with either reflector. This created an effective cavity length of at least the length of the transducers.

Inline acoustically-coupled resonator filters were presented by Staples et al. (**1976s**). Figure 11 of that paper discussed the filter bandwidth (for an unstated reflectivity) as a function of the length of the center grating, N_C. The limiting case of zero bandwidth occurs under the same conditions required for good outer reflector efficiency and there exists an upper limit in this structure of $N_C < N_R$.

The undesired loading effects led to the adoption of a synchronous placement of the transducers with respect to the reflectors, as shown in Cross et. al. **(1979c)**. Since the reflective nature of the synchronous transducers aids in energy trapping of the signal to the central cavity, the major condition is that signal from the outermost transducer electrodes be able to penetrate the transducer to reach the cavity but not be able to penetrate the adjacent reflector to leak as lost energy. This sets a maximum upper limit for the single-pole, two-port resonator to be $N_T < N_R$ and determines a transducer ratio of less than 50%, regardless of any stronger constraints related to electrical performance requirements as seen in the design examples. For the inline coupled resonator filter, at least one of the transducers adds to the shielding effect of the coupling grating and at least this transducer must be constrained such that $N_T << N_C$. Maintaining $N_T < N_C < N_R$ obtains a transducer ratio, $2N_T/(2N_T + 2N_R + N_C) < 40\%$.

It is noted that Cross et al. employed a 10% transducer ratio on quartz for his two-port synchronous resonator and that Staples and Smythe employed 2*40.5 / (2*40.5 + 2*300/2 + 150/2) = 17.8%, well under the 40% theoretical limit.

Detailed discussions of the design philosophy for an inline coupled resonator filter are given by King et al. **(1987k)**. The outer reflectors are "saturated" (>99% reflection as required by Staples (1974s), typically requiring 140 periods, and the coupling grating is partially reflective (75% - 95%), using 110 periods. The transducers were 75 and 75.5 periods long, yielding a transducer ratio of 27.7%. The RF Monolithics design minimized the outer reflectors in favor of die size and at the expense of reflective efficiency and insertion loss, otherwise the transducer ratio would likely have been even lower.

The applicant has shown design information from the literature that indicates an upper limit on the transducer ratio of 50% for simple resonators and 40% for the inline coupled resonator filter of Bulst. The applicant has shown actual examples ranging from 4% to 28%, with the applicant's own design (1987k) representing the highest transducer ratio found in the literature. While the foregoing examples are not exhaustive and the arguments are merely approximations, they serve as a basis upon which to evaluate the following design examples, and their respective frequency response models.

SINGLE POLE RESONATOR EXAMPLE:

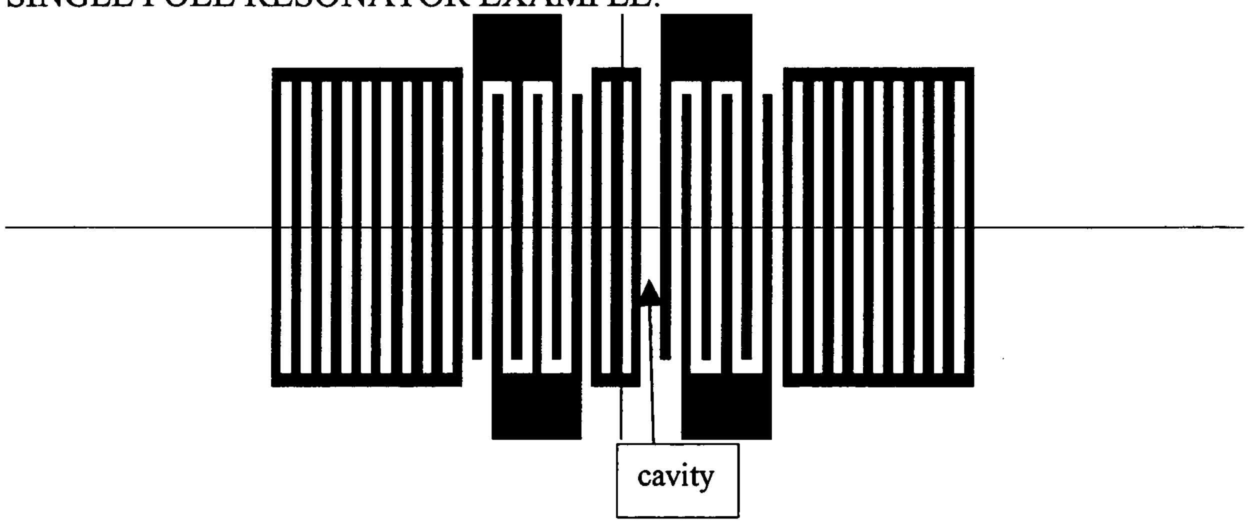

Fig. 1

Fig. 1 represents A simplified representation of a typical resonator (Note: For clarity, in this schematic simplified diagram the number of reflector and transducer elements shown have been reduced)

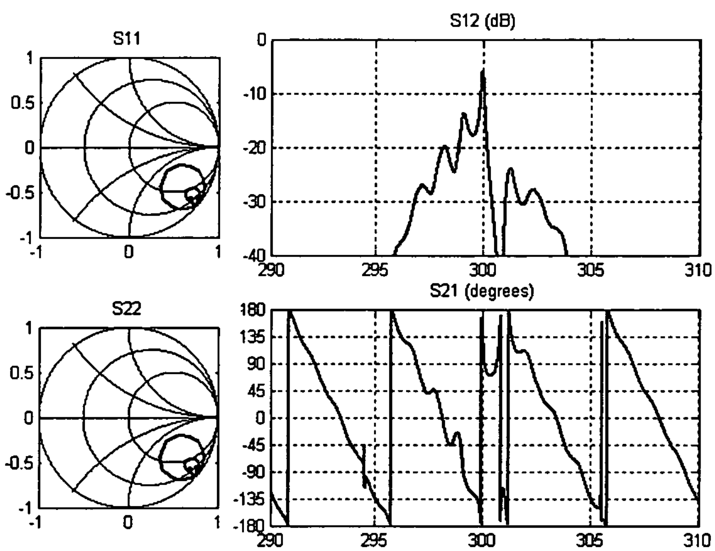

Fig. 2

Fig. 2 shows the response of a resonator marketed by RF Monolithics® circa 1986. The resonator has 100 periods (200 elements) in the reflectors and 55 periods (110 elements) in the transducers. A center reflector of 5.75 wavelengths (11 elements) is located between the transducers. In this simple one-pole resonator the ratio of the spurious resonances to the main response is the critical parameter and a minimum of 3 dB of suppression is required. The 35% transducer ratio, 110/(110+5.75+200), offers ~8 dB of suppression.

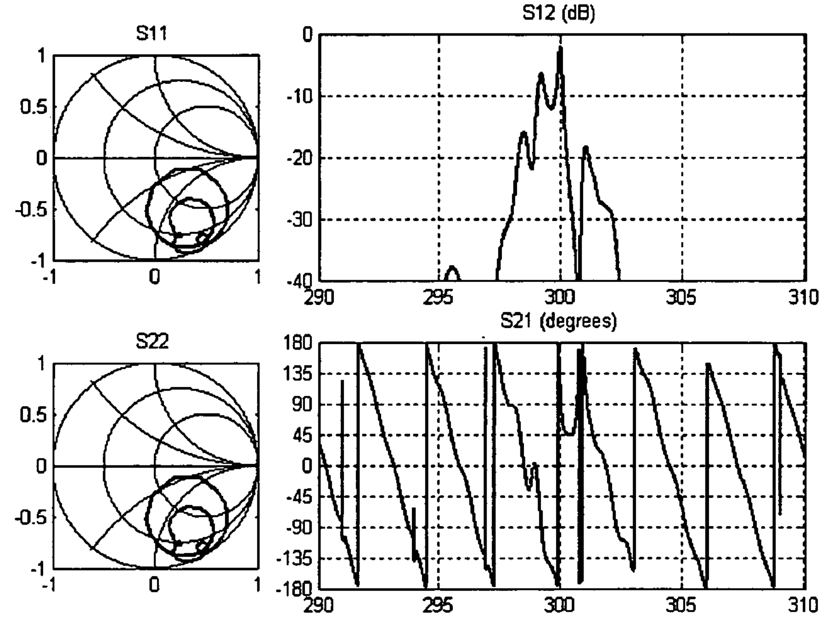

Fig. 3

Fig. 3 represents a response graph example of a similar resonator with transducer length increased to 100 periods, equal to the reflector length. The spurious response is seen to increase relative to the desired resonance at **49%** transducer ratio (theoretical maximum) with marginal (~3 dB) rejection.

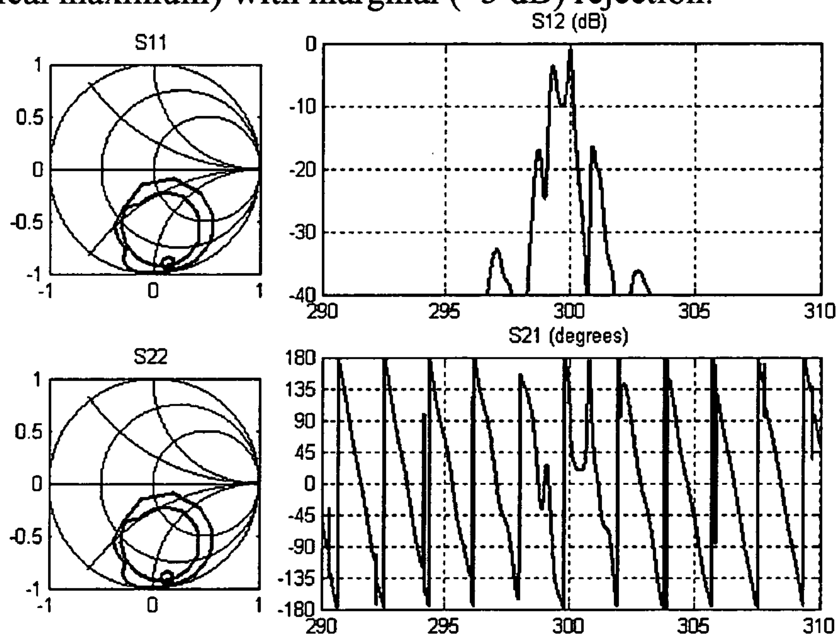

Fig. 4

Increasing the transducer to 155 periods (310 elements) reaches the **60%** threshold of transducer ratio for our class of device. As can be seen by Fig. 4, the undesired spurious resonance nearly equals the main resonance. **The electrical properties are no longer well-suited to the intended purpose of a frequency control device, supporting the assertion that the ranges in Bulst require correlation.**

TWO POLE COUPLED RESONATOR FILTER:

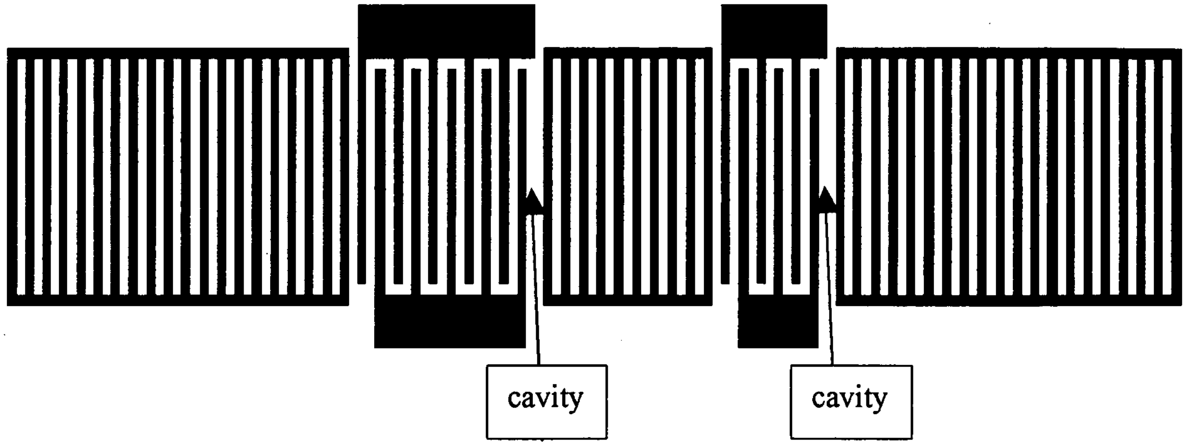

Fig. 5

Fig. 5 depicts a simplified schematic diagram of a coupled resonator filter as per Bulst with a pair of outer reflectors each adjacent to a transducer and resonant cavity (extra space to the right of each reflector), separated by a center reflector. The numbers of elements are significantly reduced for visual clarity. Aside from the addition of a second resonant cavity, this structure differs from Fig. 1 in the length of the central grating, which is chosen in conjunction with the right side transducer to give the desired transmission of signal between the two cavities.

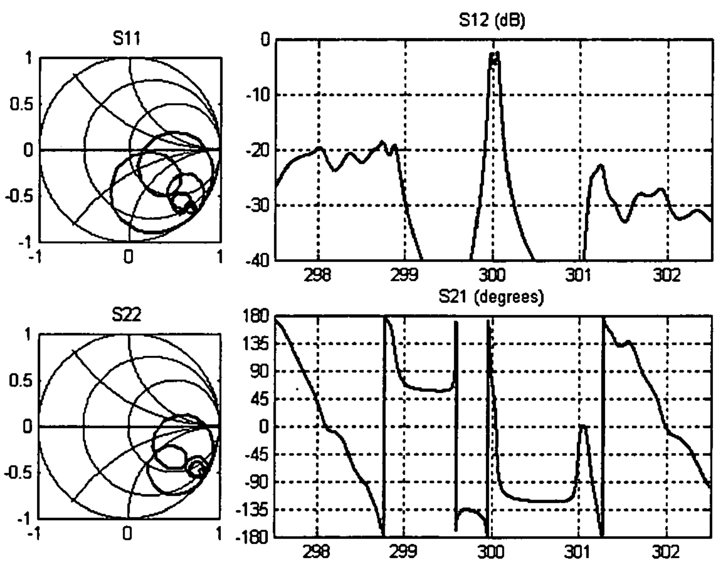

Fig. 6

Fig. 6 represents the response of a reference coupled resonator filter optimized for a ratio of reflectivity-to-piezoelectric coupling of 3:1 and employs outer reflectors of 150 periods (300 elements) and an inner reflector of 120 periods (240 elements). The transducers have 65 and 45 periods (130 and 90 elements). The transducer ratio is **21%**. The filter has good passband shape factor and > 15 dB of rejection.

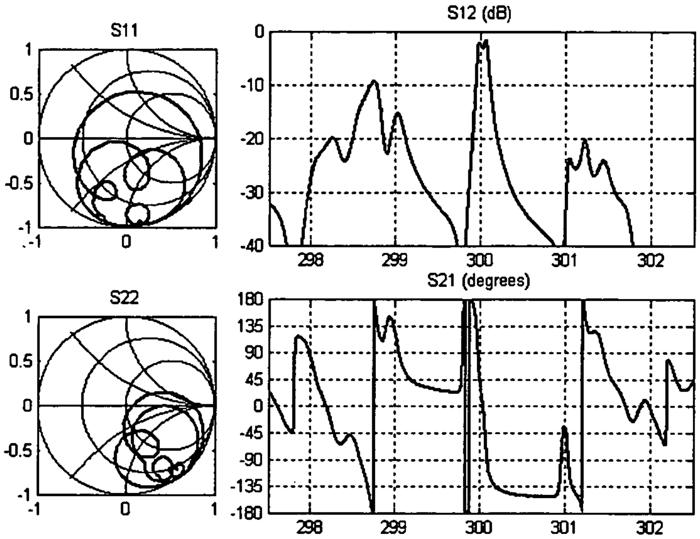

Fig. 7

Increasing the transducers to 150 and 80 periods and correcting the center grating to 80 periods still provides a suitable passband, as can be seen in Fig. 7. Despite attempts to maintain the same passband shape, the skirts are not as steep and the filter rejection decreases from >15 dB to < 10 dB. The transducer/reflector electrode ratio is increased to only **38%** (near the 40% theoretical limit) and already the filter response is significantly impaired.

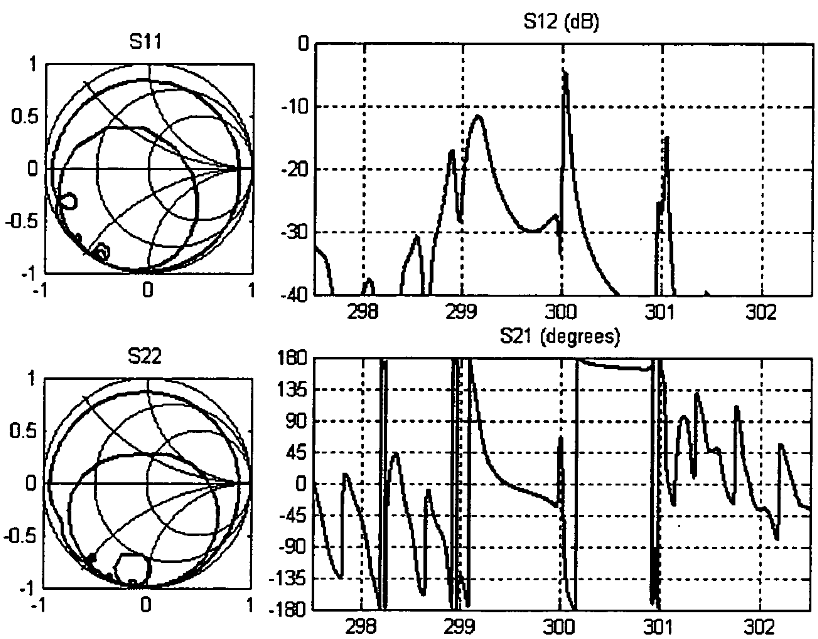

Fig. 8

Further increasing the transducers to 300 and 200 periods results in a transducer ratio of **57%** and the filter response is completely diminished, as seen in Fig. 8.

It is therefore seen that utilizing a device having the claimed transducer ratio for the MRAWD device would make a Bulst device unfit for its intended purpose, and is furthermore contrarian to the common wisdom of the state of the art of designing resonator filters. The design examples have reinforced the approximations as to the transducer ratio limits for simple resonators (50%) and filters (40%).

Assuming correlation of the ranges specified by Bulst and assuming $N_C = N_R/2$ to obtain a transducer ratio of $2N_T/(2N_T+2.5N_R)$, one obtains:
2.6% = 2*10/(2*10+2.5*300),
9% = 2*50/(2*50+2.5*400),
14.6% = 2*150/(2*150+2.5*700), and
24.2% = 2*400/(2*400+2.5*1000).

These correlated ranges are in excellent agreement with the literature examples and the successful design examples and even further relaxing the correlations implicit in the relative ranges stated would still not allow one to reach the 60% limits without taking the longest transducers in conjunction with the shortest transducers, a situation that has been argued against on fundamental terms.

The following references are filed as a part of an information disclosure statement.

1974s Staples, "UHF Surface Acoustic Wave Resonators", 1974 IEEE Frequency Control Symposium, pp. 280-285.

1975c Cross, "Reflective Arrays For SAW Resonators", 1975 IEEE Ultrasonics Symposium, pp. 241-244

1975s Staples and Smythe, "Surface Acoustic Wave Resonators On ST-Quartz", 1975 IEEE Ultrasonics Symposium, pp. 307-310

1976s Staples and Smythe, "SAW Resonators and Coupled Resonator Filters", 1976 IEEE Frequency Control Symposium, pp. 322-327.

1976h Haydl, Dischler and Hiesinger, "Multimode SAW Resonators – A Method To Study The Optimum Resonator Design", 1976 IEEE Ultrasonics Symposium, pp. 287-296.

1979c Cross, Shreve and Tan, "Synchronous IDT SAW Resonators with Q Above 10,000", 1979 IEEE Ultrasonics Symposium, pp. 824-829.

1979t Tanski, "GHz SAW Resonators", 1979 IEEE Ultrasonics Symposium, pp. 815-823. (not referenced in text)

1980s Staples, Wise, Schoenwald and Lim, "SAW Resonator 2-Pole Filters", 1980 IEEE Frequency Control Symposium", pp. 273-277. (not referenced in text)

1987k King, Heep, and Andle, "1500 MHz Coupled Resonator Filter", 1987 IEEE Ultrasonics Symposium, pp. 127-130.